MORPHOLOGY, CHROMOSOME NUMBER, AND FLAVONOID CHEMISTRY OF BIDENS CORDYLOCARPA (COMPOSITAE)

DANIEL J. CRAWFORD
Department of Botany, The University of Wyoming, Laramie 82070

Coreopsis cordylocarpa was described by Gray in 1887. For many years no one seems to have questioned that this species had an appropriate generic assignment. In his two comprehensive treatments of *Coreopsis,* Sherff (1936, 1955) does not even suggest that *C. cordylocarpa* might have been improperly placed. In his later years, however, he indicated a specimen in the Field Museum *(Cronquist 9779)* as the type of a new *Bidens* species which he proposed to name in honor of Arthur Cronquist. The name was never published, and Sherff later recognized the Cronquist specimen as belonging to *Coreopsis cordylocarpa,* and so annotated it.

My first encounter with this species in the field was in the state of Jalisco in the late summer of 1966, where I was collecting with T. Melchert and P. Sorensen. All three of us were somewhat familiar with members of the Coreopsidinae, and it seems significant that our first impression was that we were observing a species of *Bidens.* In view of this, along with the fact that Sherff had also at one time assigned this taxon to *Bidens,* a detailed study seemed indicated. The present paper gives the result of this study.

MATERIALS AND METHODS

For the cytological studies, floral buds were fixed in the field in chloroform: absolute ethyl alcohol: glacial acetic acid (4:3:1). The anthers were squashed in aceto-hematoxylin, and the chromosomes observed in dividing microsporocytes.

Leaves and flowers which were collected in the field and dried, served as one source of flavonoids for chromatographic analysis. Achenes were collected at the same time, and fresh material from plants grown in the greenhouse was also analyzed for flavonoid constituents. The floral tissues (ray floret corollas, disk floret corollas and adnate anthers, disk floret ovaries, and chaff) were analyzed separately and found to be chromatographically identical. The leaf profiles were also determined. The tissues were placed in 0.1% HCl in methanol for 24–48 hours. This extract was applied to Whatman 3MM chromatographic paper (46 × 57 cm sheets) and run in two dimensions by the descending method. The first solvent system was tertiary butyl alcohol: glacial acetic acid: distilled water (3:1:1 v/v); the second glacial acetic acid: distilled water (15:85 v/v). Drawings of these chromatograms are shown in Fig 5. In these figures each chalcone-aurone pair is designated by a single letter and represented as a single spot because they invariably occur together as a complex mixture.

Individual flavonoids were purified by repeated chromatography, and

TABLE 1.
IDENTIFICATION AND SPECIAL MAXIMA OF THE FLAVONOIDS OF C. CORDYLOCARPA

Spot Designation	Identity	Absorption maxima in mμ MeOH	+$AlCl_3$	+$AlCl_3$/ HCl	+NaOMe	+NaOAc	+NaOAc/ H_3BO_3
Leaves							
6	quercetin-3-glycoside	359	432	404	413	381	381
		295	330	365	330	325	295a
		265a	300a	300a	272	271	261
		255	274	267			
16	naringenin-7-glycoside	330	385	385	445	330	330
		283	306	306	390a	283	283
					286		
Leaves and floral tissues							
A	coreopsin	383	505a	440	450	480a	510a
		295	450	320	380a	385	413
		260	318	272	285	288	345a
		245	275	250		255a	285
			250				
A	sulfurein	403	450	405	488	487	435
		340a	342	335a	345	405	337
		274	292	275	291	340a	288
		256	255a	257		278	259
						255	
F	marein	382	520a	420	452	383	393
		320a	429	332	340	325a	320
		263	332	272	285	265	270
			273	250	253		
F	maritimein	416	455	413	497	443	442
		330	328	325	348	365	328
		273	287	273	290a	259	282
		242	248a	243	261		245
Floral tissues							
X	butein-sulfuretin mixture?	——	——	——	——	——	——

a–denotes a shoulder or inflection.

the compounds were finally analyzed spectrally, utilizing a Beckman DB-G Grating Spectrophotometer. Standard methods and diagnostic reagents were employed (Markham and Mabry, 1968; Jurd, 1962). The spectral properties of these compounds, together with their identifications, are given in Table 1.

RESULTS AND DISCUSSION

There are a combination of morphological features which serve to distinguish this species from other taxa in the genus *Coreopsis* found in

FIG. 1. Distribution of *C. cordylocarpa*.

Mexico. The (8)10-16 ray florets, club-shaped wingless achenes (fig. 3B), fruticose habit, relatively undifferentiated outer and inner involucral bracts (fig. 2B), and large (to 20 cm) pinnatisect, deltoid leaves (fig. 4A) are quite unique. Sherff (1955) treated *C. cordylocarpa* as a member of sect. *Coreopsis*. It is clearly a discordant element here, however, for all other species in this section are small annual or perennial herbs with dorsiventrally flattened, winged achenes. In fact, all species of *Coreopsis* which I have examined (primarily those from North America) have achenes which are variously flattened dorsiventrally. That Sherff placed *C. cordylocarpa* in the type section seems to indicate a lack of understanding of its affinities within the genus *Coreopsis*.

Certain morphological features of *C. cordylocarpa* are much more suggestive of some Mexican *Bidens* species than they are of any member of *Coreopsis*. Specifically, the outer and inner involucral bracts of *C. cordylocarpa* are quite similar in shape (fig. 2B), and differ primarily in color, the outer ones being dark green, whereas the inner are pale green to nearly white. These involucral characteristics are very similar to those encountered in many species of Mexican *Bidens*. In contrast, species of Mexican *Coreopsis* typically exhibit a highly dimorphic involucre with somewhat green and fleshy outer bracts which differ from the inner ones in shape, size, color, and texture (fig. 2A). Moreover, the elongate, club-shaped, terete, striate, and wingless achenes of *C. cordylocarpa* are similar in general shape and appearance to those of several species of *Bidens* from Mexico (fig. 3A, B). Certainly, the achenes of *C. cordylocarpa* in no way resemble the flat, winged fruits which are typical of all Mexican *Coreopsis,* and indeed of the genus as a whole (fig. 3B, C).

The chromosome number of *C. cordylocarpa* offers no clues as to its

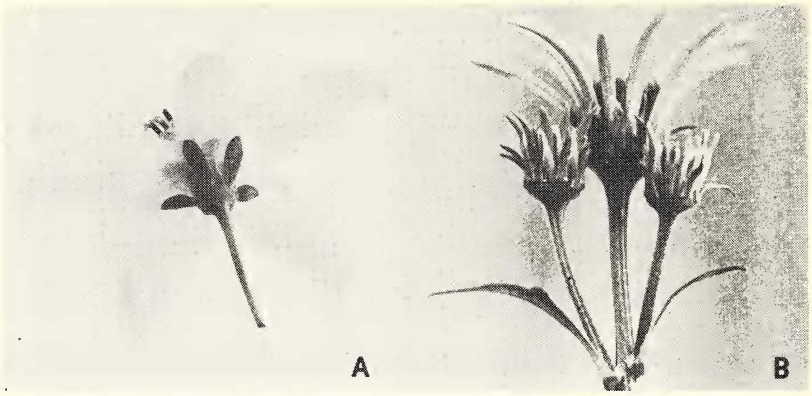

FIG. 2. Photographs of flloral heads. A, floral head of typical Mexican *Coreopsis* showing the highly dimorphic involucre; B, floral head of *C. cordylocarpa* showing the undifferentiated outer and inner involucral bracts.

generic affinities. A count of **2n = 146 ± 2** (fig. 4B) was determined in a large number of cells from *Melchert, Sorensen, & Crawford 6347A*. It must be emphasized that observations from several other populations *(Melchert, Sorensen, & Crawford 6354 & 6371; Carman 68-60)* revealed a chromosome complement of **2n = 146 ± 6-8**. From these data, it appears justifiable to conclude that only one ploidy level exists in *C. cordylocarpa,* and that probably all populations have the same or nearly the same chromosome number. This high number, unique in the Coreopsidinae and one of the highest reported in the Compositae, is particularly interesting from an evolutionary point of view when considered together with the geographic distribution and ecology of the species. *Coreopsis cordylocarpa* is endemic to Jalisco, Mexico (fig. 1) and occurs only in or along the banks of shallow streams, indicating that it may be an old species, representing the only extant taxon of an otherwise extinct polyploid complex.

The flavonoid chemistry of *C. cordylocarpa* suggests a closer affinity to other Mexican species of *Bidens* than to any *Coreopsis* taxon. As shown in Fig. 5, the leaves and floral tissues are dominated by two chalcone-aurone pairs. Coreopsin-sulfurein (spot A) and marein-maritimein (spot F) are invariably present in large quantities in both leaves and flowers. In addition, the leaves (fig. 5, left) contain a flavonol (spot 6, quercetin-3-glycoside) and a flavanone (spot 16, naringenin-7-glycoside). The flowers also contain spot X (fig. 5, right), which appears to be a mixture of butein and sulfuretin, these being the aglycones of coreopsin and sulfurein respectively.

Chemical analysis of the leaves of other suffruticose or fruticose *Coreopsis* species from Mexico (members of sections *Electra, Anathysana,* and *Pseudo-Agarista*) has revealed the complete absence of coreopsin-sulfurein and marein-maritimein. These compounds are sometimes present in the floral tissues of certain of these species, but never

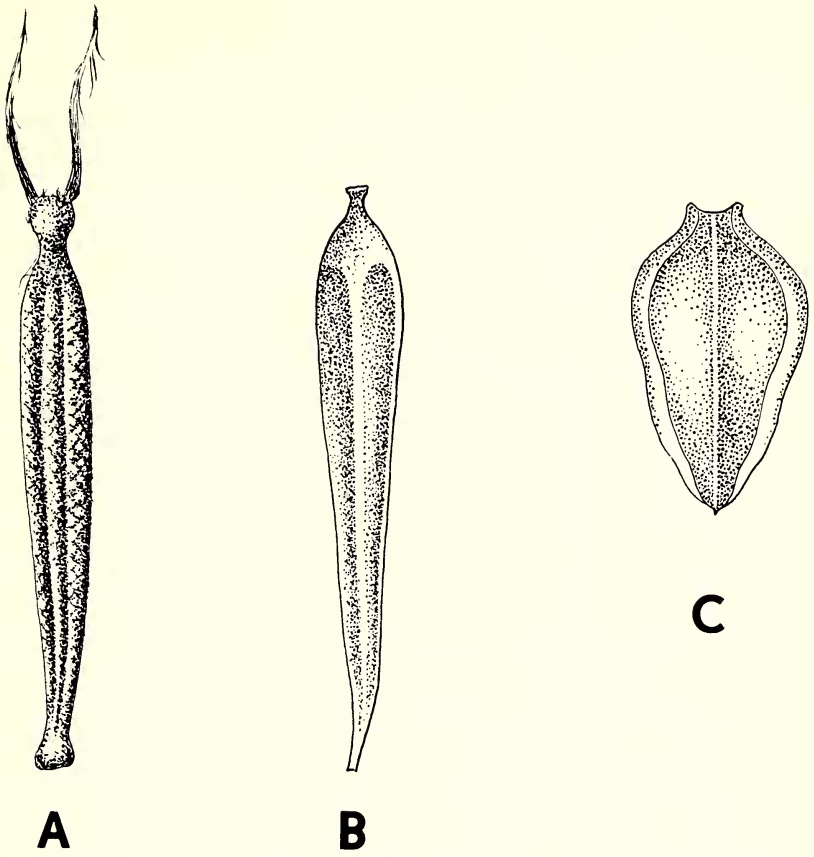

FIG. 3. Drawing of *Coreopsis* and *Bidens* achenes. A, achene of a typical Mexican *Bidens;* B, achene of *C. cordylocarpa;* C, achene of a typical Mexican *Coreopsis* (all × ca. 5).

in the leaves. It must be admitted that sufficient data are not available to make a meaningful statement concerning the distribution of these substances in the genus *Coreopsis* as a whole. However, it is instructive to compare the leaf profile of *C. cordylocarpa* to those of several species of *Bidens* from the United States and Mexico. The leaves of these taxa contain an unidentified chalcone-aurone pair which is chromatographically very similar (probably identical) to marein-maritimein. This evaluation is based upon conversations with T. E. Melchert and my observations of numerous chromatograms of the leaves of *Bidens* species. Although the chemical evidence is not conclusive, it certainly suggests that *C. corylocarpa* is much more similar to *Bidens* in its flavonoid chemistry than it is to *Coreopsis*.

Since the general morphology, as well as the preliminary chemical data, suggest that the affinities of *C. cordylocarpa* are with *Bidens* rather than with *Coreopsis,* the following new combination is proposed.

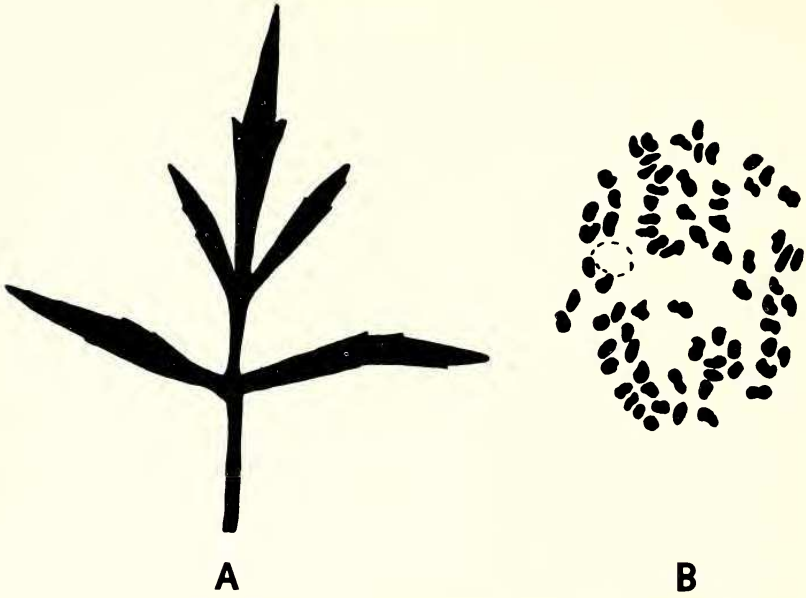

FIG. 4. A, silhouette of leaf of *C. cordylocarpa* (× ca. 1/2); B, meiotic chromosomes of *C. cordylocarpa*.

Bidens cordylocarpa (A. Gray) Crawford, comb. nov. *Coreopsis cordylocarpa* A. Gray, Proc. Amer. Acad. Arts 22:428. 1887. Fruticose, 0.5-2m tall, stems several from the base, red, hispid or with appressed hairs, becoming glabrous toward the base; leaves opposite, 10–20 cm long (including petiole), deltoid in general outline, pinnately divided, appressedly-pubescent on both surfaces; heads cymosely disposed, mostly 3-12 aggregated, peduncles 2–15 cm long, becoming densely pubescent near the involucre; heads 4–9 cm wide at anthesis; outer involucral bracts 6–10, lanceolate to narrowly so, hispid, 3–9 mm long; inner involucral bracts 8–12, lanceolate to narrowly ovate, hispid, 4–8 mm long; chaff narrowly lanceolate to linear, glabrous or sparsely hispid, 5–8 mm long at anthesis; ray florets 8–16, sometimes in a double whorl, neutral, ligule oblong to oblanceolate or linear, 0.6–4 cm long, 0.4–1.2 cm wide, entire or shallowly notched at the apex; disk florets 20–60, stigma hispid, shortly caudate; achenes club-shaped, essentially terete in cross section, glabrous, weakly striate, wingless, exaristate, and topped by a bald disk.

Representative specimens: MEXICO. Jalisco, bank of stream, 5200 ft. Sierra de San Estéban, *Barnes & Land 155* (F); banks of Río Blanco near Guadalajara, 5000 ft., *Pringle 11506* (F, MICH, MO, MSC, US); gravel along small stream 15 road mi N of Guadalajara, on road to San Cristóbal de la Barranca, 5100 ft., *Cronquist 9817* (F, MICH, MO, MSC, NY, TEX, US); in boulders and sand of stream bed leading into the barranca of the Río Blanco, ca. 8 mi N of Guadalajara, *Mel-*

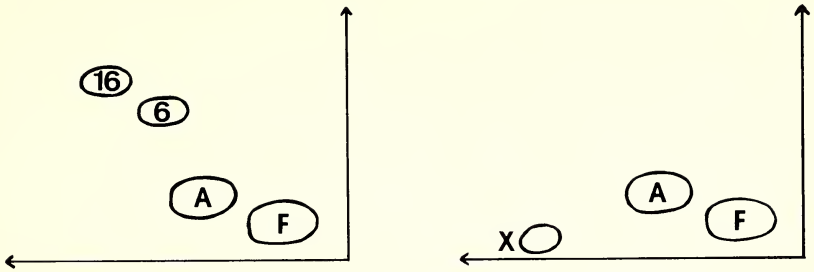

FIG. 5. Drawings of two dimensional chromatographic patterns of flavonoids in *C. cordylocarpa* (horizontal axis = tertiary butyl alcohol run; vertical axis = 15% acetic acid run); left, profile of leaves; right, profile of floral tissues.

chert, Sorensen, & Crawford 6354 (IA, RM); among boulders of swift stream, ca. 3 mi W of Cuaulta along road to Los Volcanes and Puerto Vallarta, *Melchert, Sorensen, & Crawford 6371* (IA, RM); among boulders of rocky stream bed 12.5–13 mi N of Zapopan, along dirt road to San Cristóbal de la Barranca, *Melchert, Sorensen, & Crawford 6347 A-B* (IA, RM); Hwy. 41, 7–8 mi N of Guadalajara, *Carman 68-60* (IA, RM).

ACKNOWLEDGEMENTS

The research was supported by NSF Grant GB-3851 to T. E. Melchert, University of Iowa, whose guidance during the study is much appreciated. Thanks are also due R. L. Hulbary, University of Iowa, who prepared the photographs of the floral heads, and to J. R. Reeder and Charlotte G. Reeder for helpful suggestions during the preparation of the paper. Ruby S. Quarterman, Laramie, executed the drawings of the achenes.

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NOTES AND NEWS

NOTES ON THE FLORA OF THE PACIFIC NORTHWEST.—Extensive collections from Pend Oreille Co., Washington, were made by the author in connection with a floristic study (Layser, E. F. A floristic study of Pend Oreille County, Washington. M.S. thesis, State Univ. New York, College Forestry. 1969). Among the collections, certain ones seem worth special note.

Berteroa incana (L.) DC., a weedy European crucifer, was collected along the roadside in the northern part of Pend Oreille Co. (*Layser 1175,* WS) and previously